RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced GCE

PHYSICS B (Advancing Physics) 2864/01
Field and Particle Pictures

Thursday **17 JANUARY 2001** Afternoon 1 hour 10 minutes

Candidates answer on the question paper.
Additional materials:
Data, Formulae and Relationships Booklet
Electronic calculator

TIME 1 hour 10 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Show clearly the working in all calculations, and round answers to only a justifiable number of significant figures.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- The values of standard physical constants are given in the Data, Formulae and Relationships Booklet. Any additional data required are given in the appropriate question.
- You are advised to spend about 20 minutes on Section A and 50 minutes on Section B.
- You will be awarded marks for the quality of written communication in Section B.

SECTION A

1 Here is a list of units.

ampere (A)
tesla (T)
volt (V)
weber (Wb)

Which unit from the list is the correct choice for

(a) magnetic flux, ……………………

(b) magnetic flux density, ……………………

(c) rate of change of magnetic flux linkage? …………………… [3]

2 A transformer has 400 turns of wire in its primary coil. It is used to step 240 V a.c. down to 12 V a.c.
Calculate the number of turns of wire necessary for its secondary coil.
Assume the transformer is ideal.

number of turns = …………………. [2]

3 Fig. 3.1 shows a simple dynamo.

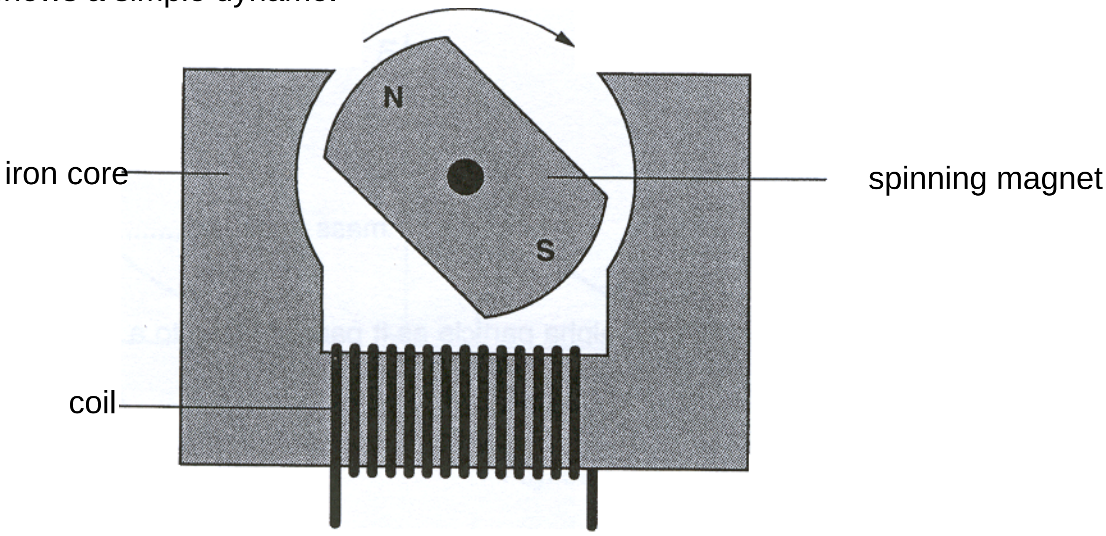


Fig. 3.1

When the magnet is rotated, the emf induced across the coil is 4V at 10 Hz.
The magnet is now rotated twice as fast.
Which of the following is the new emf induced across the coil?

A 8V at 10 Hz
B 4V at 20 Hz
C 8V at 20 Hz

answer …………………….. [1]

4 Polonium-204 is a radioisotope with a decay constant of 5.4×10^{-5} s^{-1}.
A sample of polonium-204 contains 6.0×10^{14} atoms. Calculate its activity.

activity = …………………….. Bq [2]

5 The equation shows the fusion of tritium and deuterium to form helium.

$$^{3}_{1}H + ^{2}_{1}H \rightarrow ^{4}_{2}He + \mathrm{X}$$

Particle X is one of the following.

electron neutron proton quark

X is …………………….. [1]

6 Cobalt-60 is a radioisotope which emits gamma photons of energy 1.2 MeV. Calculate the mass loss due to the emission of one gamma photon.

mass = …………………….. kg [3]

7 Fig. 7.1 shows the path followed by a 2 MeV alpha particle as it passes close to a massive nucleus.

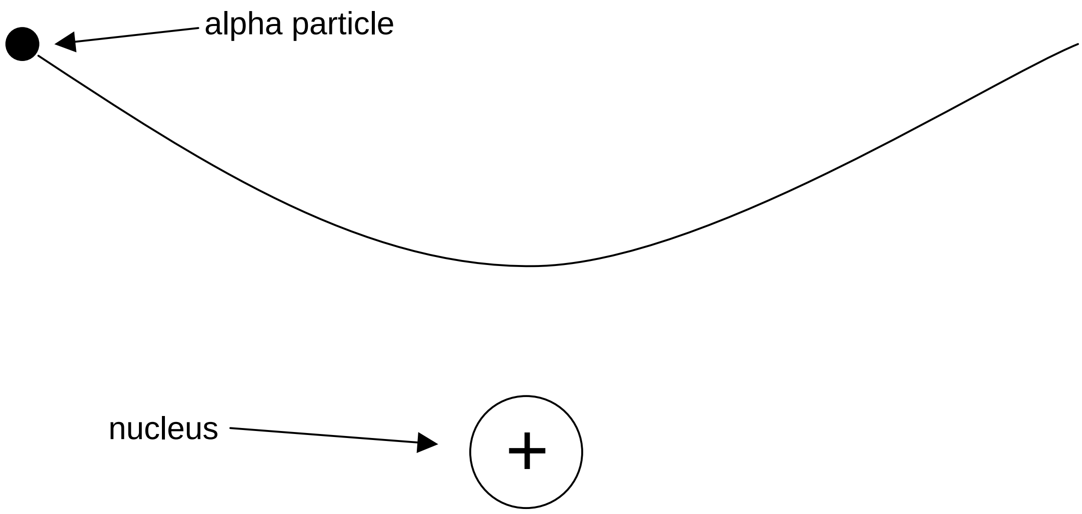


Fig.7.1

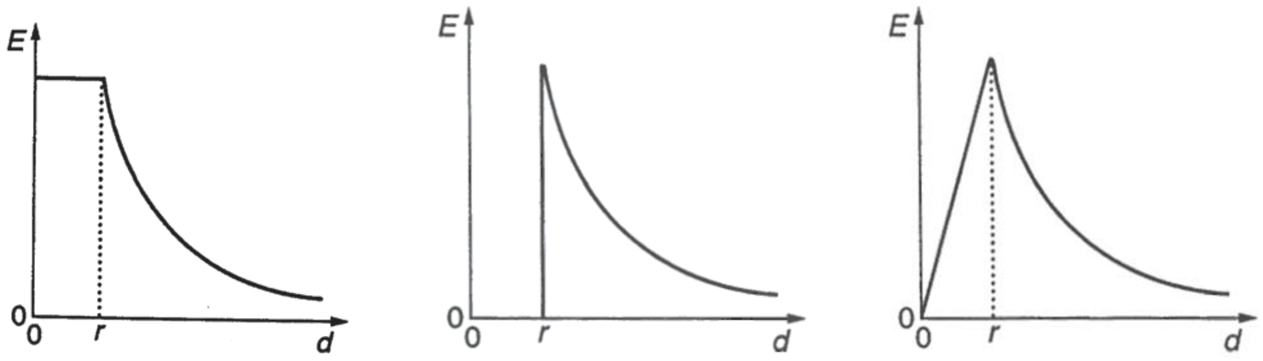
Draw on Fig. 7.1 the path followed by a 1 MeV alpha particle following the same initial path.

[2]

8 The risk of one person developing cancer from exposure to ionising radiation in their lifetime is 5% per sievert. Suppose that a worker at a nuclear processing plant has an average equivalent dose of 0.01 sievert per year. Calculate the risk of the worker developing cancer as a consequence of working at the plant for 30 years.

risk = ………………….. % [2]

9 The graphs of Fig. 9.1 show how the electric field *E* in and around a sphere of radius *r* depends on the distance *d* from its centre.



A B C

Fig.9.1

Which graph (A, B or C) is for a charged sphere made of metal?

answer …………………. [1]

10 Fig. 10.1 shows the directions of the current *I* and the flux density *B* for a wire.

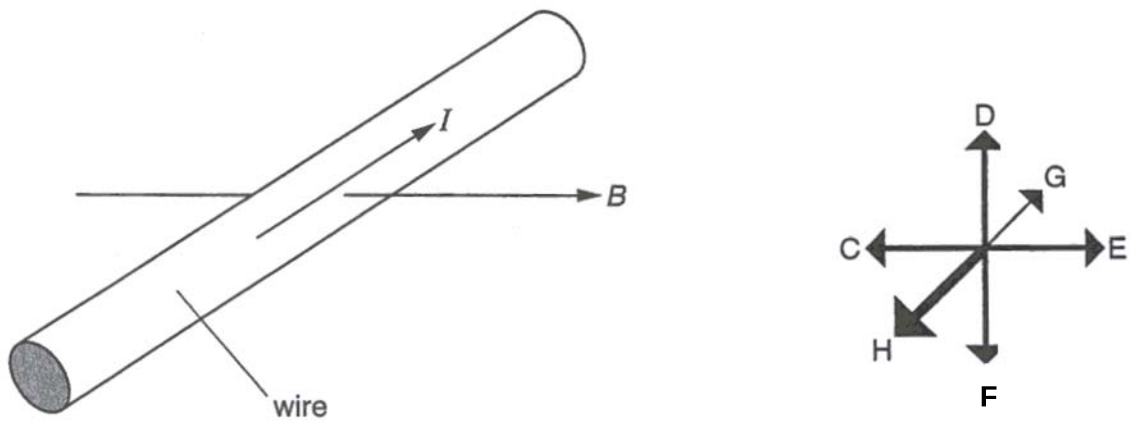


Fig. 10.1

The current interacts with the flux density to exert a force on the wire.

(a) Along which direction (OF, CE, or GH) is the force on the wire?

answer ……………….. [1]

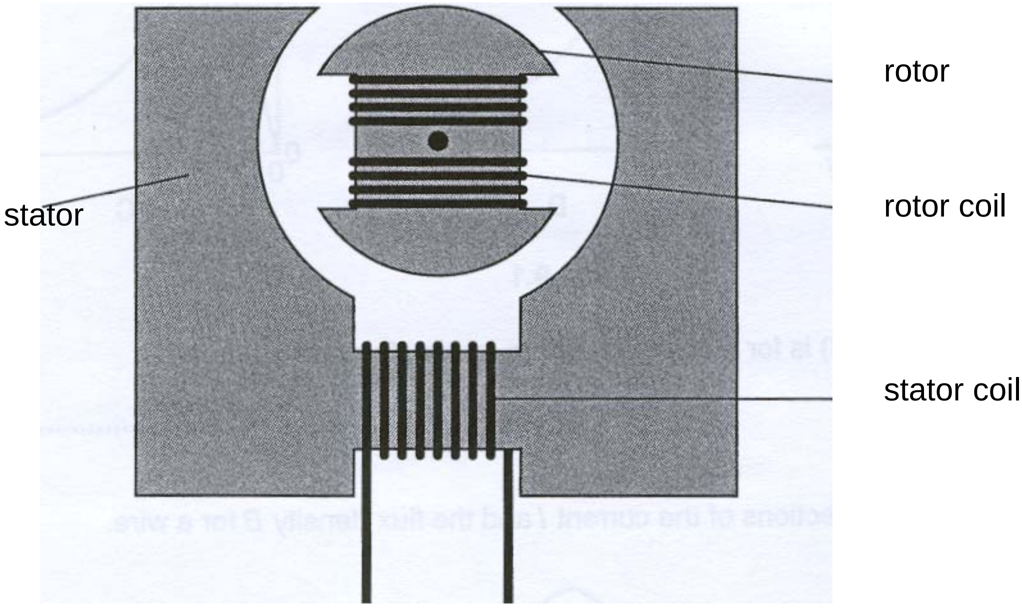
(b) The piece of wire is 8.0 cm long. The magnetic flux density is 500 mT. Calculate the force on the wire when the current in it is 420 mA.

Force = ……………………….. N [2]

SECTION B

Up to four marks in this section will be awarded for the quality of communication.

11 This question is about an electric motor, as shown below.



The rotor and stator coils are connected in parallel to the same power supply.

(a) Current in the stator coil results in magnetic flux in the stator.
The stator is made of iron. Explain why this is a good material to use.

[2]

(b) The rotor is made from thin sheets of iron, separated by thin sheets of an insulator, instead of solid iron. Explain why.

[3]

(c) The output power of the motor can be increased by increasing the voltage of the power supply.
Suggest and explain two other modifications to the motor which would result in an increased output power.

[4]

12 This question is about energy changes of particles in electric fields.

Fig. 12.1 models the decay of a plutonium-238 nucleus into a uranium-234 nucleus and an alpha particle.

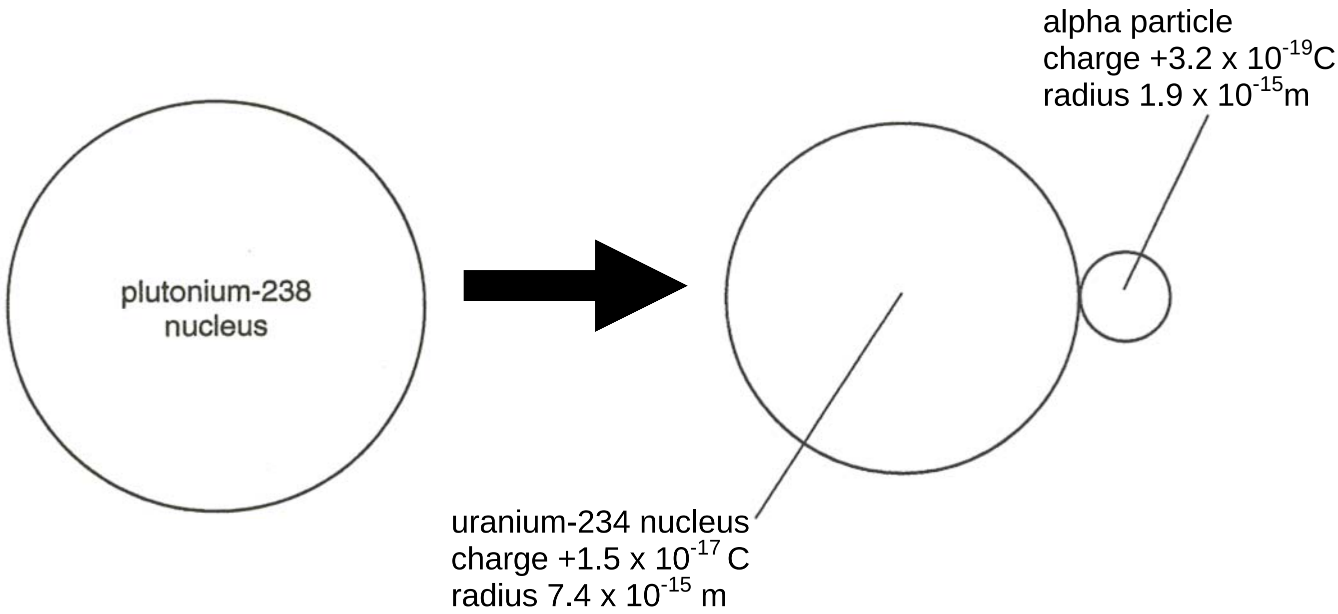


Fig.12.1

The model treats the alpha particle and the uranium-234 nucleus as charged spheres in contact immediately after the decay, with all the charge of each sphere at its centre.

(a) For the model shown in the diagram, show that

(i) the electric potential at the centre of the alpha particle due to the uranium nucleus is about 15MV,

[2]

(ii) the potential energy of the alpha particle is + 4.6 x 10^{-12}J.

[2]

(b) The model assumes that the alpha particle has zero kinetic energy immediately after the decay, and is then repelled from the nucleus by electrostatic forces alone.

(i) Estimate the final kinetic energy of the alpha particle in MeV.

energy = …………………… MeV [1]

(ii) The alpha particles from the decay of plutonium have a measured energy of 5.5 MeV.
Suggest and explain a possible reason why this is less than the value you calculated above.

[2]

13 This question is about the forces in electric fields.

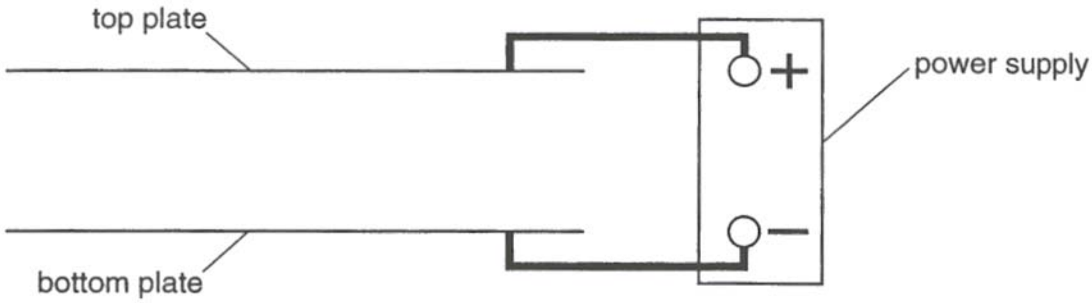


Fig. 13.1

(a) In Fig. 13.1, the plates are connected to a power supply.
Sketch five field lines in the gap between the plates.

[3]

A small metal sphere is place between the two horizontal plates, as shown in Fig. 13.2.

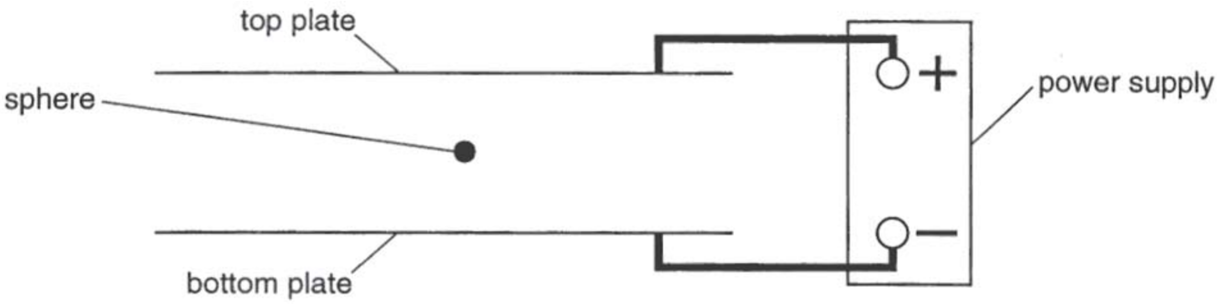


Fig. 13.2

The sphere is charged.
It does not move when the electric field is present.

(b) What sign of charge does the sphere have? Give reasons for your answer.

[3]

(c) The magnitude of the charge on the sphere is 4.8×10^{-14}C.
How many electrons had to be removed or added to give the sphere this charge?

number of electrons = ……………………….. [1]

(d) The mass of the sphere is 7.4 x 10-9 kg. The separation of the plates is 10 mm. For the sphere not to move,

(i) show that the electric field strength must be 1.5×10^{6} Vm^{-1}

[3]

(ii) calculate the potential difference required across the plates.

potential difference = ……………….. V [2]

(e) The magnitude of the charge on the sphere can be changed by exposing the air between the plates to radiation from a beta source.
Explain how this can alter the charge on the sphere.

[3]

14 This question is about the scattering of electrons from protons.

The graph of Fig. 14.1 shows the results of a scattering experiment.

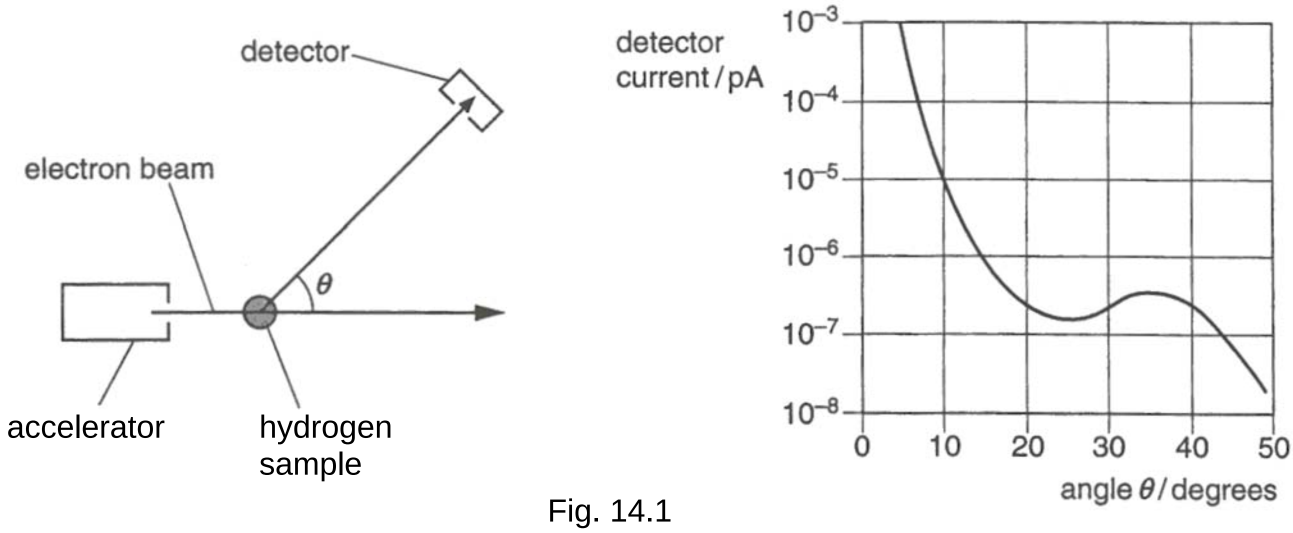


Fig. 14.1

(a) The electrons from the accelerator have a current of 50 pA. Calculate the rate at which electrons arrive at the hydrogen sample.

electron rate = …………………… s^{-1} [2]

(b) The accelerator raises the energy of the electrons to 800 MeV.

(i) Show that this is much greater than the rest energy of an electron.

[3]

(ii) The momentum p of each electron is related to its energy E by the formula $E = pc$, where $c = 3.0 \times 10^8$ m s^{-1},
Calculate the de Broglie wavelength of the electrons.

[2]

(iii) The graph of Fig. 14.1 is for electrons which are scattered elastically from the protons in the sample of hydrogen. The shape of the graph suggests a diffraction pattern.
Explain what you can deduce about the protons from the graph.

[4]

(c) At much higher electron energies, the electrons probe inside the protons. New particles, such as mesons are created.
By referring to the internal structure of a proton, explain why this can only happen at much higher electron energies.

[4]

Quality of Written Communication [4]